No. 505 New Techniques In Microscopy: Scanning Tunneling and Polarized Electron Microscopy

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As the demand for more and more detailed information about structures of microscopic dimensions increases, new and very powerful techniques are being developed. Scanning Tunneling Microscopy[1] (STM) and Scanning Electron Microscopy with Polarization Analysis[2] (SEMPA) are now being applied, respectively, to the observation of physical and magnetic microstructures.

Scanning tunneling microscopy is a technique which can be used to determine the topography of metal or semiconductor surfaces with a vertical resolution of <0.1Å and a lateral resolution of <10Å. The measurement is performed by scanning a fine metal tip a few Ångstroms above the surface to be measured and observing the tip-to-surface electron tunneling current caused by a voltage applied across the tip-to-surface vacuum gap. While scanning, a change in the height of the surface is detected through a resulting (large) change in tunneling current. In some systems, the positions of individual atoms have been observed and the geometries of surface reconstructions have been observed in real space. A wide variety of applications are being pursued including observations of various metal and semiconductor surface geometries, the topography of surfaces at atmospheric pressure or submerged under a liquid, and the imaging of molecules or biological specimens prepared on flat surfaces.

Scanning electron microscopy with polarization analysis is a new technique which directly determines the magnetic structure of a sample. The secondary electrons which are detected in a conventional scanning electron microscope, and whose intensity determines the image formed, possess for the case of a magnetic sample a preferential alignment of their intrinsic magnetic moments. The electron spins are not disoriented on being ejected from the sample and still reflect the spin ordering within the solid which gives rise to its ferromagnetism. With the addition of electron spin polarization analysis to the microscope, the size and direction of this spin alignment can be determined, giving a measure of the magnetization of the sample in a region defined by the highly focused SEM electron beam. Magnetic structures can be imaged in this manner down to the resolution of the microscope, i.e. ~50-100Å. An important characteristic of this new technique is that the intensity image of the physical structure and the polarization-derived image of the magnetic structure are completely independent, so the influence of physical structure on magnetic structure can be studied.

The physical basis, the experimental method, and some illustrative examples of each of these new microscopies will be presented.

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References:

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